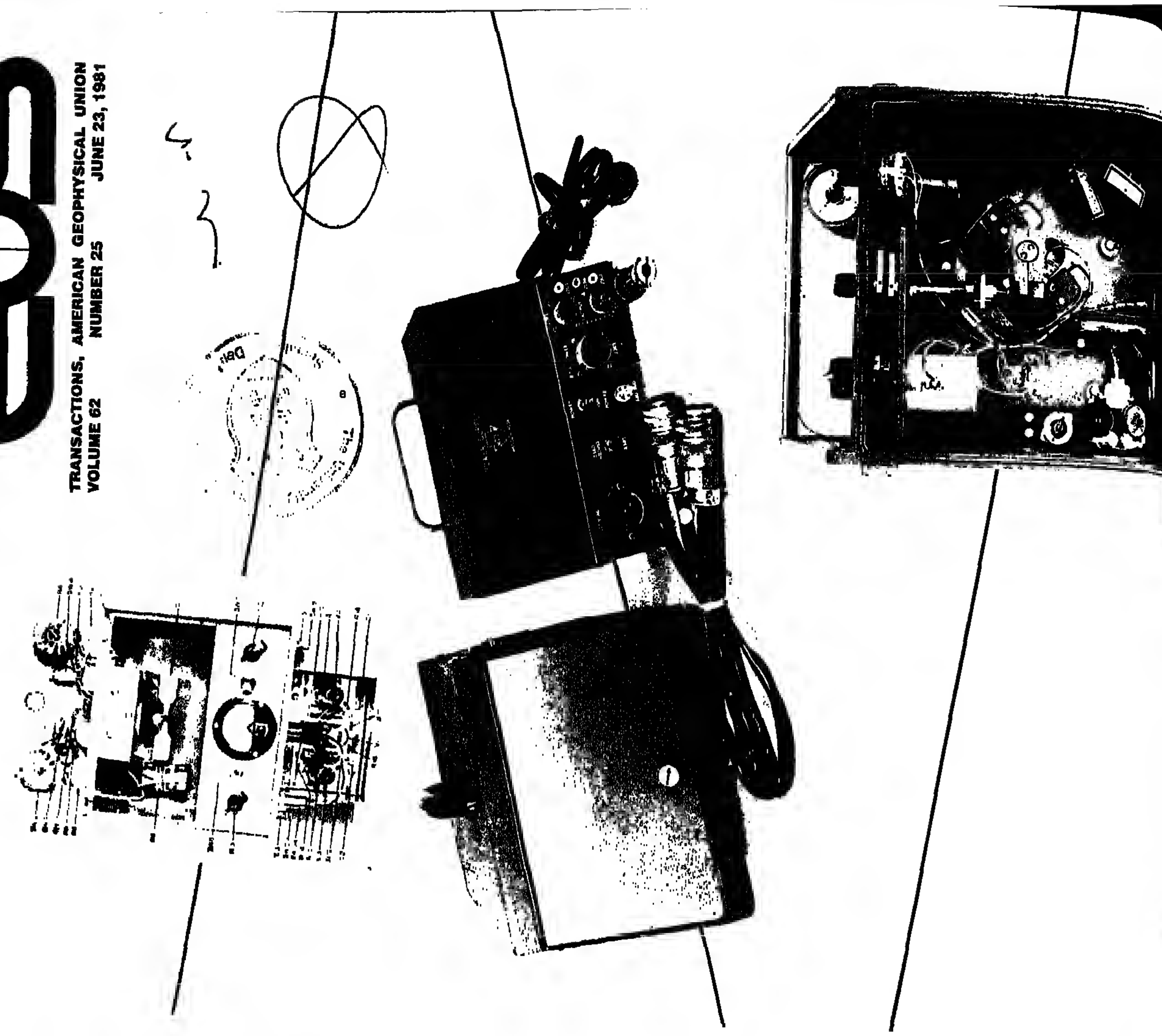


EOS, TRANSACTIONS, AMERICAN GEOPHYSICAL UNION VOL 62, NO. 25, PAGES 545-560 JUNE 23, 1981

The Commission for the Geological Map of the World and Its Future Projects

F. Delany

Secretary General, CGMW
Paris, France

From a small group of European geologists that was officially constituted during the 1881 International Geological Congress in Bologna to propose a standard legend and draft a Geological Map of Europe, the Commission for the Geological Map of the World (CGMW) has evolved into a worldwide network of cooperating geological surveys. It has contributed to progress in the earth sciences by preparing and printing maps, recognizing that these maps provide the geometric constraints for data syntheses and can, through imaginative and novel legends, demonstrate the relationship between heterogeneous parameters.

The original Bologna group was enlarged to comprise representatives of all the geological surveys of Europe, thus forming the Commission for the Geological Map of Europe, which still retains a certain autonomy within the framework of CGMW. In 1910, at the eleventh session of the International Geological Congress, when the first edition of the Geological Map of Europe was nearly ready for printing, a 1:1,000,000 geological map of the world was proposed. In view of the size of such a task, and the lack of a base map, it was decided that a world map be drafted to a 'suitable scale' according to the legend used for the Geological Map of Europe. Representatives of all countries were invited to collaborate, and thus the Commission for the Geological Map of the World came into being.

Geologists realized early that maps and sections would illustrate the three-dimensional relationships between rocks and that a great variety of their characteristics could be shown in map form by an elegant selection of colors, overprints, letters, and symbols. Fortunately, compared with a century ago, modern printing methods have increased the capacity of maps to legibly show such information.

While waiting for a world base map to become available, the CGMW initiated geological maps of continents or major regions of the world. Under the general supervision of 'continental' vice-presidents, maps of nine regions have been published. The successive editions reflect progress in geographic coverage and in detail: there are no longer mentions of 'unsurveyed,' and the subdivisions of the Precambrian, in particular, are more elaborate and precise.

In 1954, subcommissions were formed to coordinate compilation of tectonic and metallogenic maps, normally on the same geographic base as the geological maps. Later, metamorphic facies and hydrogeologic maps were undertaken, and more recently, maps showing the potential of the natural environment (which now includes hydrogeologic maps).

This succession of themes is a logical one, providing the thematic background for increasing sophisticated syntheses of topical data. Metallogenic maps, for instance, show data on mineral deposits over a background that may incorporate selected tectonic, magmatic, metamorphic, and geological features.

From about 1962 onward, the American Geographical Society started publishing the sheets of a 1:5,000,000 scale atlas. Permission was granted for CGMW to use this base for a geologic world atlas. The sheets were reduced in scale, bathymetry added, and special base maps of the ocean prepared. The Geologic World Atlas now comprises 21 sheets, of which four cover the oceans and have a special legend, one (Arctic) will show the geology of both oceans and the surrounding land mass. The legend takes up one sheet. Each sheet, or set of sheets, is accompanied by a short explanation in French and English. By 1980, 13 sheets had been published; the publication should be completed in early 1982 (index map, Figure 1).

drafting and printing. The International Union for Geological Sciences (IUGS) has provided funds for specific projects, and contracts have been executed on behalf of UNESCO for the organization of meetings, for map compilations, and for the work on the Geologic World Atlas in particular. The annual budget available to the secretariat is some FF 240,000 ($47,328). This is a ridiculously small sum compared to those invested by member countries in field mapping and compilation of regional drafts. Budget size also limits the speed with which final drafts can be prepared and the map printed. The works of all nongovernmental or scientific bodies, and in particular those associated with the International Council of Scientific Unions, are similarly restricted and will probably remain so until the efficiency and skill of these scientific bodies are adequately recognized and funding made available, even a small proportion of that contributed to intergovernmental bodies.

CGMW reports to its members by annual or biennial bulletins, and on the occasion of the 26th International Geological Congress, a catalog of maps was published (see bibliography). Lists of national and international geoscience maps, compiled by continent, disseminate essential information.

Meeting in plenary assembly every 2 years, commission members discuss every aspect of map preparation and production, from geographic base map to printing methods and from legends to lexicons. The need for an international tectonic lexicon became apparent when heated arguments arose over the meaning of some tectonic terms used in various national tectonic maps. These arguments took place in different languages and in different schools of thought, even in one and the same language. Large national lexicons were published [*Dennis*, 1967; *Murawski*, 1968–1978], and an international one [*Dennis*, 1979], restricted to terms appearing on tectonic maps in 1979.

The scales of CGMW maps vary from 1:1,500,000 (Europe) to 1:15,000,000. It was decided that the CGMW could usefully provide advice on legends and promote experi-

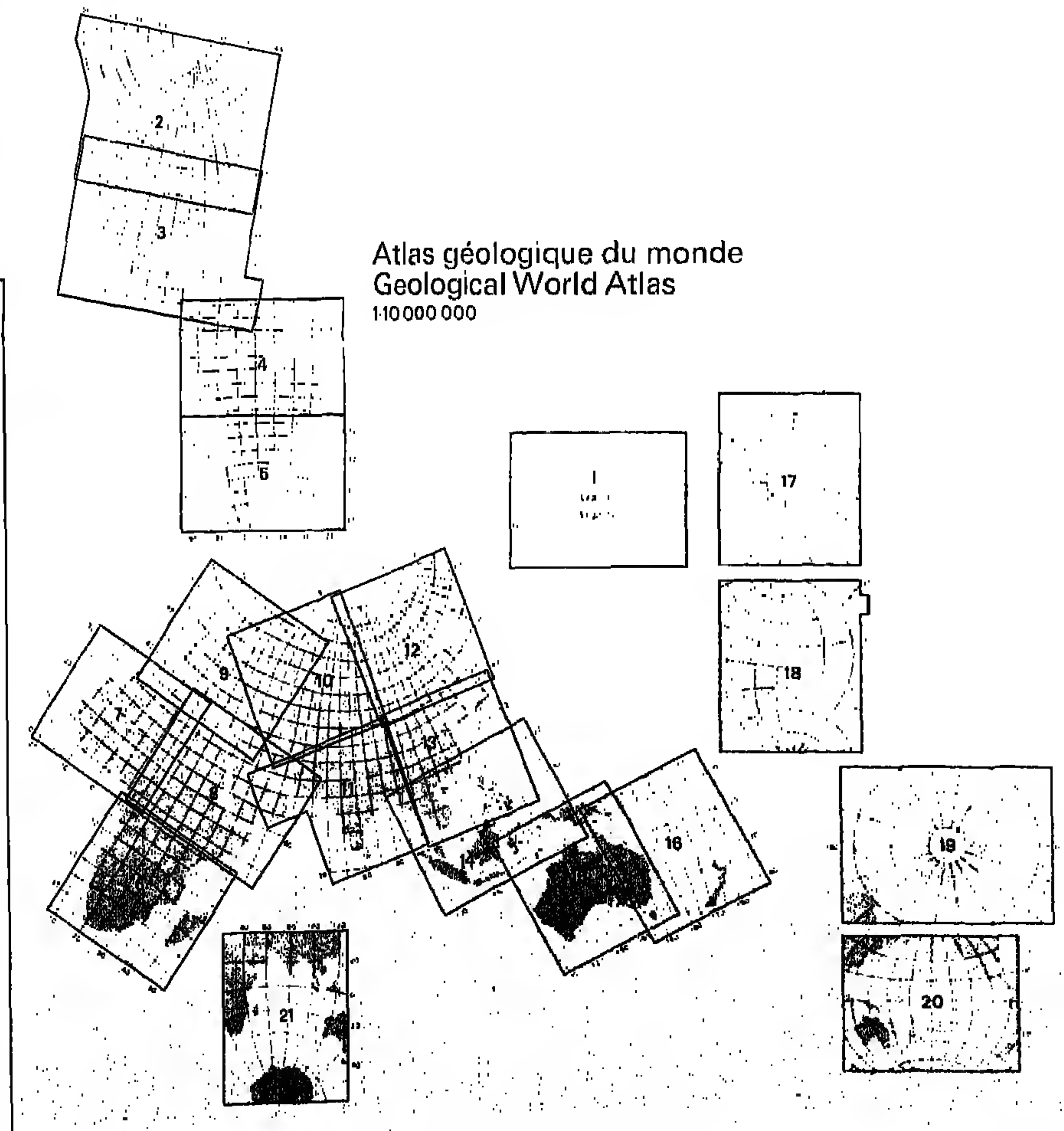


Fig. 1. Index map from Geologic World Atlas.

EOS

TRANSACTIONS, AMERICAN GEOPHYSICAL UNION

The Weekly Newspaper of Geophysics

Send double-spaced manuscript (four copies) to *Eos*, AGU, 2000 Florida Avenue, N.W., Washington, D.C. 20009, or send them directly to one of the associate editors with a copy to the above address.

Editor: A. F. Spilhaus, Jr.; **Associate Editors:** Claude J. Allègre, Peter M. Bell, Kevin C. Burke, Arnold L. Gordon, Kristina Katsaros, Gerard Lachapelle, Christopher T. Russell, Richard A. Smith, Sean C. Solomon, Carl Kisslinger; **News Writer:** Barbara T. Richman; **Editor's Assistant:** Sandra R. Marks; **Eos Production Staff:** Patricia Bangert, Margaret W. Conelley, Eric Garrison, James Hebblethwaite, Dae Sung Kim, Michael Schwartz.

Officers of the Union

J. Tuzo Wilson, President; James A. Van Allen, President-Elect; Leslie H. Meredith, General Secretary; Carl Kisslinger, Foreign Secretary; A. F. Spilhaus, Jr., Executive Director; Waldo E. Smith, Executive Director Emeritus.

Advertising that meets AGU standards is accepted. Contact Robin E. Little, advertising coordinator, 202-462-6903.

Eos, Transactions, American Geophysical Union (ISSN 0096-3941) is published weekly by the American Geophysical Union from 2000 Florida Avenue, N.W., Washington, D. C. 20009. Subscription available on request. This issue $5.00. Second-class postage paid at Washington, D. C., and at additional mailing offices.

Views expressed in this publication are those of the authors only and do not reflect official positions of the American Geophysical Union unless expressly stated.

Cover. This photo shows a thermal image of the northern part of Alaska and the pack ice of the Arctic Ocean and was taken on March 8, 1978, by the Defense Meteorological Satellite Program (DMSP). Point Barrow, the northernmost tip of the North American continent is in the center left half of the photo. Large crescent-shaped leads in the pack ice which are up to 10 km in width indicate large-scale displacement of the ice to the west. Open-water polynyas can be seen along the Chukchi Sea coast southwest of Barrow and off the Mackenzie River Delta on the upper right hand side. The area where AIDJEX, the Arctic Ice Dynamics Joint Experiment, took place (see book review in this issue) is in the center upper part of the photo. (Photo courtesy of G. Weller, Meteorology Dept., University of Melbourne, Australia.)

The other global project is the World Tectonic Wall Map, 1:15,000,000, being compiled under the leadership of V. E. Khaine (Moscow University), secretary general of the CGMW Subcommission for Tectonic Maps, with a group of coordinators from throughout the world. It is planned to use the 1:10,000,000 base of the Geologic World Atlas for other maps.

CGMW statutory members are the geological surveys, or national bodies responsible for geological mapping, of all the countries or territories of the world. Associate membership is available to other interested organizations, and to date 22 mining and oil companies have requested this association. Annual dues from members, enable the secretariat not from the French government, enable the secretariat not only to function but also to support meetings and assist

mental drafts on more detailed scales (such as those that are meaningful for hydrogeological maps and for environmental maps) but that completion of such maps would not be the commission's responsibility. This concurs with the CGMW Statutes, which state a duty to promote national maps.

Base maps pose a great problem: all normally compiled geographic maps require considerable alteration before they are suitable for a thematic map. Culture, and often hydrography, is too dense; they lack bathymetry, and place names of geologic interest need to be added. No suitable geographic base could be found for the new series of maps of South and East Asia (Iran to Japan), and CGMW compiled its own (1:5 mio and 1:10 mio).

The increasing sophistication of maps is made possible

by improved printing methods and imaginative legends and keys. The Metallogenic Map of Europe was a conjunction of screen and offset printing, where the opaque colors of screen printing, used for data on the deposits, were not altered by the underlying offset printed colors of the background. Inks can be applied in various percentages and/or with screens at different angles; simultaneous printing of three or four colors accelerates printing, and decreasing the number of times each sheet of paper goes through the press means that a different quality of paper can be used, and the process is less costly.

The CGMW sponsored a symposium on modern methods of map preparation and publication in 1979. Several of these methods are ill-suited to labor-intensive cultures but can considerably accelerate the production of maps in industrialized ones. Many countries have experimented with computer storage of the linear cartographic information, but the advantages remain uncertain. However, scanning techniques can diminish the delay between field drafts and printed maps considerably.

Following procedures that are as democratic as possible, CGMW requests each country concerned to nominate a scientist to a map editorial committee. This scientist, attending meetings of his peers, has a direct input into the international project, both at the stage of discussing the legend and by compiling his national draft. Experimental drafts are essential for proving the suitability of the legend, which is reformulated until a consensus is reached. The convenor is responsible for collating the national drafts and, normally, for seeing the map through press. Cross-frontier discrepancies apparent on juxtaposed drafts have led to international field investigations, and those, along with the continental or worldwide meetings, have strongly promoted human relationships and understanding.

The choice of the legend and its experimentation is perhaps the most exciting stage of a project.

Traditional geological maps follow a standard schema of stratigraphic subdivisions represented by conventional colors and symbols (though there are two conventional color schemes). Igneous and volcanic rocks deviate from this in that color indicates their nature (with sometimes a symbol for more detailed classification and a letter for their age). Tectonic maps have given rise to healthy debates, and typically here, what one scientist considers 'observation' can be another's 'interpretation.' For instance, the geosynclinal theory of tectonic evolution was so ingrained that maps showed only mio- and eu-geosynclines and no longer their differentiating volcanics. Only recently has the door been opened to the concept of tectonofacies, and it is now admitted (but not by all) that ophiolites and flysch and mélange should be shown as such.

Standardization of colors and symbols leads to ease of map reading, but there has evolved a somewhat too rigid differentiation between 'geologic' and 'tectonic,' etc., maps that, in many respects, hampers progress. New ideas evolving from geological maps of the deep oceans may have a healthy renovating influence on traditional land maps by breaking the formalized barriers.

New editions of the maps and the compilation of new themes provide the occasion for the introduction of modern concepts and new sets of data. Interpretation of LANDSAT imagery contributes new elements. Radiometric dating enables the Precambrian to be more precisely subdivided, and the introduction of the concept of tectonofacies provides information that is essential for theoretical interpretation of tectonic evolution—though in this field much remains to be modernized. Future innovations include the new geological maps of Africa, South America, and of South and East Asia, which will all show the geology of the continent and its margin and that of the deep oceans. The Tectonic Map of South and East Asia, to be published in 1981, comprises seven sheets: four show the tectonics of the continent and the structure of the seas (on a 1:5,000,000 scale), two give geophysical information on a simplified tectonic background (on a 1:10,000,000 scale) and one (the key) gives the tectonic stages of evolution of the various major blocks in columnar form.

The first time geophysical parameters were introduced by CGMW directly onto a map was into the ocean sheets of the Geologic World Atlas. The legend used has shown the way for depicting the ocean floor on other maps. On the new Geological Map of Africa, epicenters and magnetic anomaly patterns, as well as bathymetry, are used to delimit fracture zones and areas of oceanic crust according to their age; hollow circles are proposed to indicate observation points on magnetic anomalies, thus inferring the reliability of the information. The transition from oceanic to continental crust will be given (in five-line shading or thick lines), and the type of data on which this information is based (anomaly G, 3000-m isobath, seismic sections) will be indicated.

We have obtained a moderately good coverage of information on surface geology, and this reveals a fair amount of information on the earth's structure and evolution, but apart from deep continental drilling, the methods of investigation of the deep-seated structures are geophysical: seismic profiles and sections (deep seismic sounding and COCORP-style studies), heat-flow analyses, etc., and the correlation of these data with geological data are essential for understanding the dynamics of the earth and its deep structure. Map compilations and sections will illustrate these structures three dimensionally and also provide the geometric constraints on interpretation of data.

It is of course possible to plot geophysical data on a topographic map and thus illustrate the spatial distribution of properties of the earth's crust, but a compilation will have greater significance when plotted on a selected background of geologic, tectonic, and structural information. Elegantly juxtaposed sets of parameters would highlight relationships known, inferred, and unknown: one set constituting the background theme and another, or others, the main topic of the map. For instance, a thermal régime map might include in the background information on metamorphism (facies and age), volcanics and intrusions (age, nature and chemistry, depth of intrusion), faults (younger than a given age?, extension at depth, inferred- or observed-type of fault, and magnitude of displacement), and the topics might include heat-flow data, depth of Moho & Conrad discontinuities, hot springs, thermal waters, etc. A suitable imaginative selection of colors, lines, symbols, and overprints would enable a very considerable amount of information to be illustrated and legibly presented.

An association of seismic data (natural and controlled source) with heat flow, gravity, faults, etc., should outline lateral inhomogeneities in the crust and their surface effects.

If a major attempt is to be made to locate and understand inhomogeneities in the lithosphere, as outlined in the initial recommendation of the International Lithosphere Project (ILP), maps and deep sections would be an easy and graphic method of compiling, presenting, and correlating data. A rapid sketch to produce an inventory of information already to hand would stress regions demanding attention. A final draft in 10 years time would summarize progress achieved during the ILP.

CGMW desires greatly that this new generation of maps be a cooperative effort between IUGG and IUGS bodies so that optimum input of scientific expertise be available. The IUGG bodies most likely to be interested are associated in particular with the International Association for Seismology and Physics of the Earth's Interior (IASPEI) and include the International Heat Flow Committee, the Commission on Controlled Source Seismology, the IAGA working group on magnetic maps, the International Gravity Bureau, as well as the European Seismological Commission. The IASPEI General Assembly in London, Ontario, later this year, appears a suitable occasion to constitute one or more joint IASPEI-CGMW task groups to propose general outlines for perhaps two projects: crustal structure and heat flow.

The slow evolution from purely chronostratigraphic maps to those incorporating geophysical data corresponds to the trend to integrate earth science disciplines; such cooperation so highly successful in the international programs of the past decades (the Upper Mantle Project and the International Geodynamics Programme) is being applied in the newly launched International Lithosphere Project. The preparation of maps touches every stage of data collection and interpretation; they allow for the participation of all countries and for a wide range of disciplines. The geological-geophysical maps envisaged would comply with many of the recommendations of the ILP and contribute significantly to its success.

References

Dennis, J. G., International Tectonic Dictionary, *AAPG Mem. 7*, 196 pp., 1967.
Dennis, J. G., H. Murawski and K. Weber (Eds.), *International Tectonic Lexicon, A Prodrome*, Schweizerbartsche Verlag, Stuttgart, 153 pp., 1979.
Murawski, H., 1968–1976, Deutsches Handwörterbuch der Tektonik, B. G. R., Hannover (loose leaf).

Bibliography

MAPS

Africa

Base Map of Africa, 1:20,000,000 and 1:10,000,000, ASGA/UNESCO, 1967 (azimuthal postel projection, 1936).
Tectonic Map of Africa, 1:15,000,000, CGMW/UNESCO, 1969, (azimuthal postel projection, 1936).
Coal Map of Africa, 1:10,000,000, with explanatory notes, ASGA/ECA, 1966, (azimuthal postel projection, 1936).
Mineral Map of Africa, 1:10,000,000, with explanatory notes, 1968, ASGA/UNESCO, 1969, (azimuthal postel projection, 1936).
Iron Ore Deposits in Africa, 1:10,000,000, ASGA, 1970, (azimuthal postel projection, 1936).
Metamorphic Map of Africa, 1:10,000,000, CGMW/UNESCO, 1978, (mercator, transverse).
Geological Map of Africa, 1:5,000,000, 3rd ed., in press (mercator transverse).
Tectonic Map of Africa, 1:5,000,000, 1968, 9 sheets with explanatory notes, ASGA/UNESCO, 1969 (azimuthal postel projection, 1936).
Tectonic Map of Africa, 1:5,000,000, 9 sheets, CGMW/UNESCO, 1972.
Metallogenic Map of Africa, 1:5,000,000, ASGA/CGMW, in press.

Antarctica

Tectonic Map of Antarctica, 1:10,000,000, with explanatory notes, 1980. Convenors: C. Craddock, G. Grikurov.
Metamorphic Facies Map of Antarctica, M. G. Ravich (compiler), 1:5,000,000, 1980.
Geological Map of Antarctica, CGMW S/C for Antarctica, 1978 (polar projection).

Asia, South & East

Geographic Base Map, South & East Asia, 1:10,000,000 and 1:5,000,000, CGMW/Geol. Surv. India.
Metamorphic Map of South & East Asia, 1:10,000,000, in [illegible] Convenor: Sang Man Lee (Korea).
Geological Map of Asia and the Far East, 1:5,000,000, 2nd ed., sheets, with explanatory notes (English/French), ESCAP/UNESCO, 1971 (Lambert conical orthomorphic).
Geological Map of South & East Asia, 1:5,000,000, 3rd. ed., in press, Convenor: Director General, Geol. Surv. India.
Tectonic Map of South & East Asia, 1:5,000,000, 7 sheets, in press. Convenor: D. K. Ray, Geol. Surv. India (Lambert conical orthomorphic).
Metallogenic Map of South & East Asia, 1:5,000,000, in press, Convenor: K. Kanehira (Japan).

Australia and Oceania

Geological Map of the World, Australia and Oceania, 1:5,000,000, sheets 2–6, 10–12, BMRGG, Canberra 1966–68 (Lambert conform conical projection).
Geological Map of the World, Australia and Oceania, 1:5,000,000 sheets 9 and 13, Geol. Surv. N.Z. 1966–68 (Lambert conform conical projection).
Metallogenic Map of Australia-Oceania, 1:5,000,000, in press. Convenor: BMRGG, Canberra (Lambert conform conical projection).
Metamorphic Map of Australia, in press. Convenor: T. G. Vallance.

Europe

Tectonic Map of Europe and Adjacent Regions, 1:10,000,000, 1979, Convenor: V. Khain, Yu Leonov, CGMW/Academy of Sciences, Moscow.
Tectonic Map of Europe, 1:2,500,000, 1st ed., 18 sheets, Ed. Comm. Tectonic Map of Europe, Moscow Univ. (Lambert conform conical projection).
Tectonic Map of Europe, 1:2,500,000, 2nd ed., 18 sheets, in press, CGMW/Academy of Sciences, Moscow.
Carte Métallogénique de l'Europe, 1:2,500,000, diff. dates, 9 sheets + legend, Ed. Comm. Metal. Map Europe, BRGM/UNESCO (Lambert conform conical).
Metamorphic Map of Europe, 1:2,500,000, 18 sheets with explanatory notes, 1978. Convenor: H. J. Zwart, CGMW S/C Metamorphic Maps/UNESCO.
Carte Internationale des Gisements de Fer de l'Europe, 1:2,500,000, diff. dates, 18 sheets, BGR (Lambert conform conical).
Carte Internationale des Dépôts Houillers, 1:2,500,000, 18 sheets, (Russian/French), Academy of Sciences, Moscow 1968 (Lambert conform conical).
Geological Map of Europe, 1:1,500,000, diff. dates, 3rd ed., 49 sheets, BGR/UNESCO (Lambert conform conical).
Hydrogeologic Map of Europe, 1:1,500,000, with explanatory notes, diff. dates, CGMW S/C Hydrogeological Maps & AIH, BGR/UNESCO (Lambert conform conical).
Metamorphic Map of the Alps, 1:1,000,000, 1 sheet, 1988. Convenor: H. J. Zwart, CGMW S/C Metamorphic Maps/UNESCO.

North America

Geological Map of North America, 1:5,000,000, 2 sheets, USGS, 1965, (Albers equal area projection).
Tectonic Map of North America, 1:5,000,000, 2 sheets, USGS, 1969, (Albers equal area projection).
Metallogenic Map of North America: 1:5,000,000, in press. Convenor: Ph. Guild, USGS.

South America

Geological Map of South America, 1:5,000,000, 2 sheets, 1964, DNPM, Brasilia (conform conical bipolar oblique).
Geological Map of South America, 1:5,000,000, 3rd ed., in press.
Tectonic Map of South America, 1:5,000,000, 2 sheets, DNPM/GSA, 1979 (conform conical bipolar oblique).
Metallogenic Map of South America, 1:5,000,000, in press, 2 sheets. Convenor: C. Menin, Venezuela.
Metamorphic Map of South America, 1:5,000,000, in press. Convenor: F. Hervé, Chile.

National and International Geosciences Maps

Africa, 2nd ed., 1979.
Alps, Mediterranean Basin, and adjacent regions, 1972.
Europe, 2nd ed., 1980.
South America, 1973.
Asia and Far East, 1973.
Australia, Oceania, 1973.
Middle East, 1973.

CGMW Bulletins

Annual or biannual (27 published to date).

A Kenya childhood followed by multilingual education in Switzerland (at Lausanne and the ETH-Zurich) led Francois Delany to field work in Africa (Sudan, Equatorial Africa, and Kenya) and, as geologist of the BRGM (Orléans), to secretary general of the CGMW. She was formerly secretary general of the Inter-Union Commission on Geodynamics.

Forum

An Open Letter to the Members:

Back in the 30's and 40's when we old timers were interested in geophysics, it was especially for our particular field (geodesy, seismology, geomagnetism, meteorology, oceanography, etc.), which the NAS-NRC had grouped together for the U.S. participation in the International Union of Geodesy and Geophysics. Through the meetings and publications of the AGU, and through the work of the more forward-looking members, the interrelationships of these individual disciplines began to develop. Geophysics took on a broader meaning. In the early 1950s when plans were initiated for the Third International Polar Year, the title became the International Geophysical Year. The efforts were to involve intensive studies of the environment of the earth in space, of the ocean floor, and, especially, in the Antarctic. The term 'geophysics' came into broad common usage. The modern-day profession of geophysicist had been born, and a member became proud to be called a geophysicist.

My connection with AGU and geophysics began in 1930 when I came in from Ohio to attend the annual meetings. In 1944 I became AGU's first full-time executive officer. Then for more than 25 years I had a close association with the growth and development of geophysics. Now, after 10 years of retirement, I am glad to observe that the development has continued. AGU is a healthy, dynamic organization.

Through all these years, the AGU, though quite poor financially, has always been solvent. It still is. Now I am glad to join the incumbent officers in believing that AGU should not have just a hand-to-mouth existence, but should be put on a more firm basis. To this end the officers have wisely, I believe, invested AGU's limited surplus, gathered slowly (and rather painfully) over the years, as the down payment on the building which serves as its home, its investment and a hedge against inflation. I think that the membership, recognizing the above and other related facts, will want to rise to the occasion and make substantial and tax-deductible contributions to the cause.

Thus, as an old-timer in AGU, I am writing to you, the members—many of whom I know—to enlist your assistance. There are a variety of ways you can help this effort: for example (1) a single direct contribution, (2) a series of contributions over a period of 5 years, (3) a provision in your will stipulating a specific amount or percent or, (4) a living trust giving you, the donor, a life interest in the income. Another way you can help is a personal letter to AGU with any constructive suggestions you may wish to offer to aid us in this financial appeal. By all means, be an embassador of good will.

With memories of 'the good old days' and with warm regards,

Waldo E. Smith

Song of the Geophysicists

Little drops of water, little grains of sand
Make the mighty ocean and the pleasant land.

Underneath the sands and the ocean deep,
We have the mantel, core and crust; we hearken to their beep.

Also the atmosphere and above the sky so blue.
All are parts of geophysics, indeed a splendid slew.

Now the gifts of our good members, who in the thousands are,
Can make this job a great success, and bring us out at par

The author apologizes to Julia A. Fletcher Carney and wishes to remain anonymous

News

Nuclear Waste Disposal: Subseabed Option

Research on options for nuclear waste disposal in the oceans, as opposed to disposal on land, is being done because of mounting difficulties of site management: some political, others geological. 'The Ocean, as a commonly owned (or unowned) resource, is not protected by market place and political forces,' according to K. S. Kamlet (*Oceanus, 24*, Spring 1981). Societal restrictions and a relatively unstable geological environment are problems that would be minimized in the use of ocean sediments as a disposal site for high-level nuclear wastes.

There are strong proponents for using the oceans and ocean floors as a repository for waste. For example, in a recent article (*Oceanus*, sup.), E. D. Goldberg of Scripps Institution on Oceanography states:

> Compelling propositions can be formulated to show that marine disposal can in some instances offer economic, social, and scientific advantages over the other two options—atmospheric and land disposal. I . . . consider the information base, developed during the last three decades from investigations in marine pollution, for the profane position. For the most part, these studies have attempted mainly to protect public health, but the importance of maintaining viable communities of marine organisms has not been unrecognized. Perhaps there are greater areas of common ground among the involved scientists than may be evident from initial assessments of their positions. All aim to preserve the renewable resources of the oceans and to maintain public health.

In a brief to the U.S. House of Representatives' Subcommittee on Oceanography, D. R. Anderson stated last December,

> The use of the ocean sediments as a repository for high-level nuclear wastes would offer a number of advantages to land-based mined repositories. First, the areas of the ocean that would be suitable for disposal offer a very predictable geologic environment. The central portions of the oceanic plates have the lowest seismic activity on earth. Areas can be chosen that have no volcanism. The continuously depositional nature of the central gyre areas of the ocean is remarkably insensitive to climatic changes. Second, the oceans present an unsurpassed natural barrier to man's intrusion to the repository. The deep sea floor is perhaps the least valuable property on earth. The clay sediments (essentially dust blown off the continents) is of no commercial value. Manganese nodules of high copper and nickel content are concentrated in areas of the ocean that are being avoided even though the collection of nodules from the sea floor above a repository would be unlikely to disturb the repository. We cannot trust societal controls to prevent intrusion into the repository for the 10,000 year minimum life of a repository. Thus, it is significant that a society less technically advanced than our own would simply be unable to disturb the repository. The cannisters placed in the deep sea sediments would be essentially independent of each other. Any operation that disturbs one or a few cannisters would not degrade the barrier properties of the remainder of the repository. These first two features are very important since EPA calculations on mined repositories indicate that almost all of the risk of a repository is associated with unexpected breaching of a repository. The third desirable feature of the ocean sediments is that they are structurally a very simple geologic formation. The sediments are uniform over a great horizontal extent and are free from faults, fissures or cracks. This means that the models that are developed to predict the behavior of waste movement (beyond the heated zone) in the far field will be relatively simple and less difficult to verify. The far field will be the barrier after a cannister fails and will be the barrier for perhaps 90% of the lifetime of a repository. Fourth, the maximum temperature that the sediment will experience occurs within about 2 years after emplacement and the heat will begin to dissipate into the ocean after 15 years allowing us to experiment and monitor in real time the worst case conditions that will exist in the repository. This is a result of the relatively short distance between the heat source of the waste cannister and the heat sink of the ocean's waters and the high thermal conductivity of the sediments. The deeper a heat source is placed in a geologic media the longer it takes for the heat pulse to pass through the surrounding media.

Meteorological Records Set in Winter of '80

The winter of 1980–1981 produced monthly and seasonal records and near records for the country and nearly half the states.

Nationwide, NOAA said January 1981 was the driest since 1895 and the fourth driest month during the 87 years national averages have been kept. A 48-state total average precipitation for the month was 0.92 inches, compared with the 87-year average of 2.21.

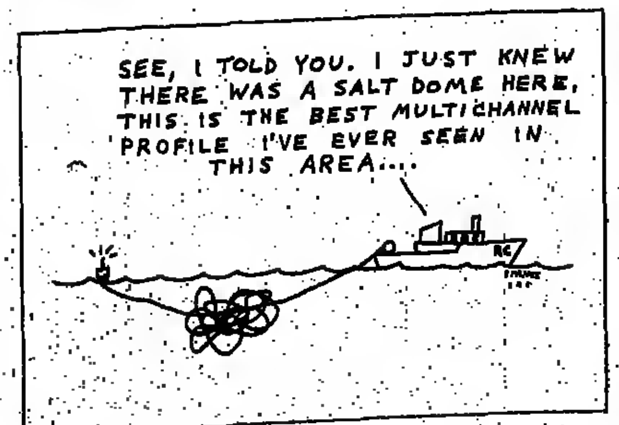
December through February also was the second driest period in record-keeping history.

NOAA's National Climatic Center compiled this list for the season:

Alabama—third driest January, third driest winter.
Arizona—second warmest January, warmest winter.
Arkansas—third driest winter.
California—second warmest January, warmest winter.
Colorado—driest winter, second warmest January, second warmest winter.
Connecticut—second driest January.
Delaware—driest January, driest winter.
Florida—second coldest January.
Georgia—second driest January.
Idaho—third driest January.
Illinois—driest January.
Indiana—driest January.
Iowa—driest January.
Kentucky—driest January.
Louisiana—driest winter.
Maine—second coldest January.
Maryland—driest January, third driest winter.
Massachusetts—coldest and second driest January.
Mississippi—second driest January, driest winter.
Montana—warmest and second driest January.
West Virginia—driest January.
Wisconsin—driest January.
Wyoming—third driest winter, second warmest January, second warmest winter.

NOAA satellite measurements also revealed that the January snow cover over North America was the lowest since measurements began in 1966.

Last winter was the fifth consecutive one in which temperatures in much of the eastern United States were below the long-term average. The states suffering this string of cold winters were Michigan, Illinois, Indiana, Ohio, Pennsylvania, Delaware, Kentucky, Virginia, West Virginia, Arkansas, Tennessee, North and South Carolina, Louisiana, Mississippi, and Georgia. [Source: NOAA]—*PMB*



U.S. Vulnerable to Major Hurricane

The nation is 'in the most vulnerable position in history' should a major hurricane strike this year, according to James P. Walsh, acting NOAA Administrator.

He warned that mushrooming coastal populations, public inexperience and apathy, and limited evacuation routes could combine to create a major catastrophe.

Under today's conditions, Walsh said, a far smaller storm than the hurricane that killed 6000 persons in Galveston in 1900 could bring a far more tragic disaster.

Although it is impossible to predict that a recent downturn in large hurricanes will be reversed, Walsh said, neither is there reason to believe the United States will be spared. And, he pointed out, tracks for 31 killer hurricanes of this century show that no area of the South or East has been spared.

The absence of killer hurricanes in the past several years has bred a dangerous degree of apathy, and studies have shown a marked reluctance by people in the path of a storm to leave in adequate time, Walsh said. 'Every year a few thoughtless persons even hold hurricane parties, sometimes with tragic consequences,' he observed.

Despite steadily improving forecast and warning performances by the National Weather Service, and total cooperation by the media in informing the public, the 12-hour period between warning and landfall will not guarantee safety, Walsh said, 'and in numerous cases it requires 18 to 24 hours to mobilize and carry out an evacuation.'

Although the hurricane season officially began June 1, Hurricane Arlene preceded that date by 3 weeks. [Source: NOAA]—*PMB*

Reclaiming A Name

The Bureau of Reclamation, which became the Water and Power Resources Service in November 1979, will regain its original name, Department of Interior Secretary James Watt announced recently.

'The name Bureau of Reclamation is one of historical significance as well as a symbol of excellence,' Watt said. 'Changing the name to Water and Power Resources Service was a mistake. The public we serve did not like it, nor did the employees who loyally worked for it. The name proved to be awkward, difficult to use in speech and writing, and lacked a logical and convincing short form as a ready reference.'

Watt estimated that reclaiming the bureau's name will save taxpayers nearly $1.5 million in printing and sign changes that will not have to be made.

Mount St. Helens Visitors Need Permit

Scientists doing research on Mount St. Helens are required to obtain a permit, according to the U.S. Forest Service. The permits are designed to reduce risks to individuals by requiring radio communications and safety precautions. The Forest Service also hopes to reduce overall risk by limiting the number of people in the area at any given time.

Permits are available for all scales of research projects. Inquiries and applications should be made well in advance of planned projects. Contact Charles Caughlan, Emergency Coordination Center, U.S. Forest Service, 500 W. 12th Street, Vancouver, WA 98660 (telephone: 206/696-7853).

Geophysicists

Vernon C. Bissell has been selected as the hydrologist in charge of NOAA's River Forecast Center in Portland, Ore. He succeeds *Donald W. Kuehl*, who is retiring.

John C. Gergen has been appointed project manager of the North American Datum Readjustment program in the National Geodetic Survey.

New Publications

Sea Ice Processes and Models

Robert S. Pritchard (Ed.), Pergamon, New York, xiv + 474 pp., 1980, $30.00.

Reviewed by Gunter Weller

Sea Ice Processes and Models deals primarily with the scientific results of AIDJEX, the Arctic Ice Dynamics Joint Experiment. Although papers on AIDJEX continue to be published, *Sea Ice Processes and Models* provides the final summary, under one cover, of the major scientific achievements of that experiment on the sea ice of the Arctic Ocean. Not all of the papers in the volume are on AIDJEX, however, but the majority are, and many of the others were influenced by it. AIDJEX was probably the most comprehensive and sophisticated experiment on large-scale sea ice dynamics ever carried out in the West, and its success is reflected in the quality and quantity of its numerous scientific publications, which are contained in scientific journals and the 40 or so AIDJEX Bulletins that appeared over the years.

The present volume summarizes the results of field studies and modeling experiments of sea ice movement and deformation on different space and time scales. This involves the determination of internal and external forces, including the stresses exerted on the ice by the ocean and the atmosphere, which are influenced by the processes and structure of the boundary layer in both media. However, atmospheric and oceanic processes not only directly influence sea ice behavior, but are in turn influenced by the extent and characteristics of the ice through feedback processes. The organization of papers on such a variety of topics is clearly difficult, and the editor of the volume has solved this, not quite satisfactorily in this reviewer's opinion, by having only four major, loosely structured sections. The first of these is straightforward enough since it deals entirely with AIDJEX summary overviews. Norbert Untersteiner, AIDJEX's director, discusses the AIDJEX philosophy and history, followed by Coon on the modeling program, Paulson on the atmospheric program, and Hunkins on the oceanographic program.

In the second, rather large, section of 17 papers headed 'Deterministic Sea Ice Model Development,' a variety of topics are presented. Several large-scale dynamic/thermodynamic models, including the AIDJEX model, are discussed by Pritchard, Hibler and others, as are experiments to verify the models, as for example, in Hall's paper on determining ice displacement vectors derived from satellite imagery. These models generally start out with a momentum equation, but since the velocity and stress of the ice cannot be determined directly from the momentum balance, ice velocities as a function of internal stress are expressed through the use of a constitutive law and yield criteria. The yield criterion depends on the strength of the ice and therefore on the ice thickness distribution, which, as Rothrock shows, can be determined as a function of the thermal and mechanical history of the ice in the area. Sea ice thickness also affect its surface temperature and albedo as well as its strength. Yield and plastic deformation in ice crushing failure are discussed by Ralston.

Field observations of sea ice processes occupied the center of the stage in AIDJEX and are the main topic of the third section. This involved establishing three manned and numerous unmanned stations on the drifting ice to generate a data set suitable for testing concepts and ideas. A variety of techniques and problems are discussed in the papers of this section, including drifting buoy position measurements, analysis of sonar and laser profiles of sea ice, radar transponder measurements of ice motion, and meteorological energy balance measurements to determine the thermodynamic response of the ice to atmospheric and oceanic processes. Two papers on the climatological and statistical predictability of sea ice extent are also included in this section. One of them, Walsh's, uses empirical orthogonal function analysis to suggest that there may be well-defined situations where ice anomalies lead to atmospheric anomalies. The final section contains eight papers on atmospheric and oceanic boundary layer structure and processes, and the determination of accurate barometric pressure fields, from which air stress can be calculated.

Sea ice studies had not received a great deal of attention in this country prior to AIDJEX and were allowed to lapse again after the completion of that experiment. Only recently, under the impetus of the need to recover the offshore petroleum resources in the Arctic, has this interest been revived. In this area we are lagging behind the Soviet Union which has a well-organized, long-term arctic research effort. Despite some national and international conferences on sea ice prior to AIDJEX, the classic Soviet book by Zubov, *Arctic Ice*, written in 1945, remained the main source of information on arctic sea ice. AIDJEX and some of the other studies that it inspired have represented a quantum jump forward, however, and the result—*Sea Ice Processes and Models*—is without doubt the most significant recent addition to our understanding of arctic sea ice.

Gunter Weller is with the Geophysical Institute, University of Alaska, Fairbanks, Alaska.

Classified

EOS offers classified space for Positions Available, Positions Wanted, and Services, Supplies, Courses, and Announcements. There are no discounts or commissions on classified ads. Any type that is not publisher's choice is charged for at display rates. EOS is published weekly on Tuesday. Ads must be received in writing on Monday 1 week prior to the date of the issue required.

Replies to ads with box numbers should be addressed to Box ___, American Geophysical Union, 2000 Florida Avenue, N.W., Washington, D.C. 20009.

POSITIONS WANTED
Rates per line
1–5 times—$1.00, 6–11 times—$0.75,
12–26 times—$0.55

POSITIONS AVAILABLE
Rates per line
1–5 times—$2.00, 6–11 times—$1.60,
12–26 times—$1.40

SERVICES, SUPPLIES, COURSES, AND ANNOUNCEMENTS
Rates per line
1–5 times—$2.50, 6–11 times—$1.95
12–26 times—$1.75

POSITIONS AVAILABLE

Faculty Positions. The Department of Ocean Engineering is seeking qualified individuals to join its research engineering staff. Recent doctoral graduates, as well as those with experience, are invited to submit resumes for consideration. While we are particularly interested in strengthening our programs in underwater acoustics, instrumentation and signal processing, we are also interested in coastal zone dynamics and related engineering problems. A graduate program in marine biology, chemistry, geology and geo-physics, physical oceanography and ocean engineering offers opportunity for teaching and supervision of graduate level research. Salary and position will be commensurate with qualifications. If interested contact: Department Chairman, Ocean Engineering Department, Box 54P, Woods Hole Oceanographic Institution, Woods Hole, MA 02543.

An equal opportunity employer M/F/H.

Scientist. Immediate opening for Scientist with experience in Lidar Analysis Techniques and Optics. Familiarity with Laser and Optics Instrumentation a plus. Candidate must possess a PhD in Atmospheric Science/Optics/Physics.

Send resumes to: Melba Houston, Technical Recruiter, Systems and Applied Sciences Corporation, 6811 Kenilworth Avenue, Riverdale, Maryland 20840.

An equal opportunity employer.

Faculty Position/Humboldt State University, Arcata, California. Applications are invited for a temporary appointment at lecturer equivalent to assistant professor in micropaleontology, paleontology, stratigraphy and petroleum geology in the geology program to teach undergraduates. Applicants should have a Ph.D. in geology and demonstrated teaching ability. Participation in lower division teaching and senior thesis research supervision is expected. Candidates must solicit three letters of recommendation, and send transcripts of academic work and a summary of personal and professional data to Dr. K. R. Aalto, Chairman, Geology Department, Humboldt State University, Arcata, California 95521. Applications will be accepted until October 15, 1981.

Humboldt State University is an equal opportunity affirmative action employer.

Geophysical Oceanography Postdoctoral Research Associate. The Department of Oceanography, University of Washington, is seeking qualified candidates for a Post-doctoral Research Associate position, available January 1982, to carry out research on interpretation of marine refraction data. A strong background in elastic wave propagation, inverse theory (including linear programming), and modern refraction data processing will be most helpful, as will an acquaintance with petrologic theories of oceanic lithospheric composition. Appointments are for one year, possibly extended for a second year. Send curriculum vitae and a list of four references to: Chairperson, Faculty Recruitment Committee, Department of Oceanography WB-10, University of Washington, Seattle, WA 98195.

The University of Washington is an equal opportunity affirmative action employer.

Electron Microprobe Technical Specialist/University of Colorado. The department of Geological Science, University of Colorado, Boulder, seeks a person who will assume responsibility for the department's electron microprobe laboratory. Duties will include day-to-day operation of our MAC 400 microprobe equipped with a KEVEX EDS system, instruction of new operators, maintenance of the microprobe as well as other X-ray equipment within the Department, microprobe software and hardware development, and participation in research projects involving silicate, sulfide and oxide mineralogy. The job requires either a degree in electronic or electrical engineering, or two years of technical experience utilizing electronic instrumentation associated with an electron column instrument. An individual with an M.S. degree in Geology and microprobe experience will be considered highly desirable. Salary ranges from $20,000–$25,000 depending on experience. Please send, by August 15, letter of application and resume to Bruce Bad-ger, Personnel Department, University of Colorado, 1511 University Avenue, Boulder, CO 80309.

The University of Colorado is an equal opportunity/affirmative action employer.

Sedimentologist or Sedimentary Petrologist/University of California, Santa Barbara. (Correction) Applications are invited for a tenure track appointment in soft rock geology to be filled in 1981–82. Rank dependent on qualifications and experience but preference will be given to the assistant professor level. Applicant should normally have a Ph.D. and strong field-orientation and quantitative background. The candidate will be expected to develop a strong research program in sedimentation. The candidate will also be expected to teach at both undergraduate and graduate levels and interact with students and faculty of the department, particularly in the general areas of diagenesis, volcanic processes, paleomagnetics, as well as field geology. Additional duties may include teaching physical geology and summer field geology.

Please send resume, other documentation of abilities, and four letters of recommendation by September 30, 1981 to Dr. Arthur G. Sylvester, Chairman, Department of Geological Sciences, University of California, Santa Barbara, CA 93106. Telephone (805) 961-3156.

The University of California is an affirmative action/equal opportunity employer.

Postdoctoral Research Associate/University of Kansas. Temporary postdoctoral research associate in space plasma physics, 6 months appointment with renewal possibility, at the University of Kansas Department of Physics and Astronomy. The work is on a plasma simulation project on planetary magnetospheres. Ph.D. required. Curriculum vitae, bibliography, and three letters of recommendation must be received by Thomas Armstrong, Department of Physics and Astronomy, University of Kansas, Lawrence, Kansas 66045, on or before July 27, 1981.

The University of Kansas is an equal opportunity employer. Women and minorities are encouraged to apply.

Scripps Institution of Oceanography

is soliciting applications for a postdoctoral fellowship in any aspect of marine geology, marine geochemistry, or marine geophysics for one year beginning fall 1981. Applicants should submit names of three references, bio-bibliographies, reprints, and a statement of research interest. Preference will be given to recent Ph.D.s. Salary will be approximately $19,500 depending upon experience and publications.

No moving expenses can be paid. Submit applications to Chairman, Geological Research Division, A-020, Scripps Institution of Oceanography, La Jolla, CA 92093, no later than August 1, 1981.

The University of California, San Diego is an equal opportunity/affirmative action employer.

Meteorologist/Remote Sensing. Immediate opening for candidate with a PhD in Meteorology with post graduate research experience and interest in Remote Sensing.

Send resumes to: Melba Houston, Technical Recruiter, Systems and Applied Sciences Corporation, 6811 Kenilworth Avenue, Riverdale, Maryland 20840.

An equal opportunity employer.

Postdoctoral Research Associate. Postdoctoral research associate position in environmental modeling available immediately in the Joint Institute for Advancement of Flight Sciences (JIAFS). The Joint Institute is a cooperative research and education program between The George Washington University and the NASA Langley Research Center and is located at NASA-Langley, Hampton, Virginia. Background in data analysis, photochemistry and middle atmospheric studies required. Salary commensurate with qualifications. Send resume to Dr. J. L. Whitesides, Assistant Director, JIAFS, George Washington University, NASA-Langley Research Center, MS 169, Hampton, VA 23665.

The GWU is an equal opportunity/affirmative action employer.

Faculty Position/Geophysics. The Department of Geological Sciences at the University of Texas at El Paso has an opening in geophysics which can be filled at either the assistant or associate professor level. The emphasis will be on obtaining a quality individual regardless of specialty. However, candidates who would complement existing programs in geothermics, crustal studies, seismotectonics, and regional geophysics/tectonics will be given preference. The successful candidate must hold a doctoral degree and will be expected to maintain a high level of research activity and to be active in the geophysics graduate program which involves 15–20 students (roughly ½ doctoral candidates). The geophysics program is well equipped and enjoys good support from the university administration. The deadline for applications is July 15, 1981 with the position to be filled prior to September 1, 1982. Applications and three letters of reference should be sent to:

Dr. Robert F. Roy
Department of Geological Sciences
University of Texas at El Paso
El Paso, Texas 79968.

The University of Texas at El Paso is an equal opportunity/affirmative action employer.

Atmospheric Scientist/Group Head. Senior staff scientist position available immediately at the NAIC's Arecibo Observatory. The successful applicant will be appointed as Head of the Atmospheric Sciences Group and will be expected to lead that group and to perform independent research using the Arecibo facilities. A Ph.D. degree in atmospheric or physical sciences or radar engineering and a record of solid research accomplishments are required. Experience with radar studies of the stratosphere, mesosphere, and ionosphere or with HF modifications of the ionosphere is desirable. Salary open. Please send resume and names of at least three references to Dr. Harold D. Craft, Jr., Director, Arecibo Observatory, Space Sciences Building, Cornell University, Ithaca, New York 14853.

NAIC/Cornell University are EOE/AAE.

Petrology Position Open. The Department of Geological Sciences at Columbia University invites applications for a research appointment in either igneous or metamorphic petrology, possibly with an orientation towards ore deposits. The successful candidate would have research interests involving quantitative analysis of rocks. Research would be carried out at the Lamont-Doherty Geological Observatory. Special funding arrangements and participation in the instructional program are expected. Rank and salary dependant upon qualifications. Candidates should submit curriculum vitae and the names of three referees to Professor W. S. Broecker, Lamont-Doherty Geological Observatory, Palisades, New York, 10964 by July 14, 1981.

Columbia University is an equal opportunity employer.

Geophysicist/Tectonophysicist. The Department of Geology and Geophysics at the University of Wyoming has a tenure track opening at the Associate Professor level for a geophysicist/tectonophysicist. An interest in velocity measurements and other physical properties of rocks is essential. Additional interest in crustal structure and plate tectonics is desirable. Applicant should be able to relate studies of physical properties to field relationships. Ph.D. required.

Applications will be accepted through July 15, 1981. Applicants should send a vita, including names of three references, to:

Professor R. S. Houston
Department of Geology/Geophysics
University of Wyoming
Laramie, Wyoming 82071

The University of Wyoming is an equal opportunity/affirmative action employer.

Faculty Position Space Physics & Astronomy

The Department of Space Physics and Astronomy of Rice University expects to fill a regular faculty position beginning August 1982. Academic rank and tenure status will be determined on the basis of experience.

Preference will be given to experimentalists who are Principal Investigators for experiments on present or planned spacecraft missions. However, consideration will be given to other qualified candidates in the general areas of space physics, astrophysics, and atmospheric science.

Applicants should send resumes and bibliographies to

Professor A. J. Dessler
Chairman
Department of Space Physics and Astronomy
Rice University, Houston, TX 77001.

Rice University is an equal opportunity/affirmative action employer. No candidate is presently under consideration in advance of this notice.

Physical Oceanographer/Geophysical Fluid Dynamicist

Areté Associates, a growing research firm, located in Southern California, engaged in theoretical and empirical physical oceanography, is offering permanent, full-time positions. Candidates require Ph.D. (or equivalent experience) in physical oceanography or geophysical fluid dynamics. Salaries are competitive and negotiable, based on qualifications. Areté offers a fringe benefit package of superior quality. Qualified candidates should send résumé, salary history, and list of professional references to:

Personnel Administrator
Areté Associates
P.O. Box 350
Encino, CA 91316

An equal opportunity employer M/F.

Temporary Staff Positions in Isotope and Trace Element Geochemistry. The research program of the new Geochemistry Division at the Max-Planck-Insitute for Chemistry in Mainz is oriented toward the geochemical structure and development of the earth's mantle. Our facilities include a new Varian MAT 261 automated solid source mass spectrometer (in addition to older instruments) for isotopic analysis of Nd, Sr, and Pb.

Available at the Institute are also: electron microprobe, ion microprobe, INAA, XRF, spark source MS, and piston-cylinder apparatus. Applications are invited for geochemists with experience in isotope geology and petrologists with experimental experience in trace element partitioning. Appointments are normally made for two years, but a one year extension is possible.

Applications should be sent to A. W. Hofmann, Direktor Abteilung Geochemie, Max-Planck-Institute fuer Chemie, Postfach 3060, 6500 Mainz, F.R. Germany.

Research Position/Space Plasma Physics. Applications are invited for two possible research positions in the Department of Space Physics and Astronomy, Rice University.

One position involves work on a computer code for simulating the large-scale dynamics of the earth's ionosphere and magnetosphere, including computer simulation of specific events and comparison with ground and satellite data. Preference will be given to applicants having experience with space or laboratory plasma physics, and with large computations.

The second possible position involves analysis of data from Atmospheric Explorer and Dynamics Explorer spacecraft. Preference will be given to applicants having experience with space plasmas and with reduction of spacecraft data.

Title and salary for either position will be arranged, depending on experience. Please send resume and bibliography to R. A. Wolf or P. H. Reiff, Department of Space Physics and Astronomy, Rice University, Houston, TX 77001.

Rice University is an equal opportunity affirmative action employer.

Physical Oceanographer. A postdoctoral research position in physical oceanography is available at the University of North Carolina at Chapel Hill, to begin as early as August 1981. Ph.D. with background and interests in mesoscale Gulf Stream dynamics, geophysical fluid dynamics, or ocean acoustics are encouraged to apply. Initial appointment will be for one year with a possible continuation through a maximum of three years. Please send vitae and the names of three references to Professor John M. Bane, Marine Sciences Program, 12-5 Venable Hall 045A, University of North Carolina, Chapel Hill, North Carolina 27514.

The University of North Carolina is an affirmative action/equal opportunity employer.

Postdoctoral Position in Geochemistry/Cosmochemistry, University of Arizona. Applications are invited for a postdoctoral research associateship in the Lunar and Planetary Laboratory at the University of Arizona. The associate will collaborate with Dr. William V. Boynton in ongoing investigations of the refractory inclusions in carbonaceous chondrites. The selected applicant will have major responsibilities to conduct mineralogical investigations to supplement existing neutron activation analysis studies. Experience with an electron microprobe is essential; experience with neutron activation is desirable. Facilities include a fully automated SEM microprobe, numerous gamma-ray detectors including a Compton-suppression spectrometer, several computers and a TRIGA reactor.

Applications, accompanied by a resume, statement of research interests, and complete bibliography, should be sent to Dr. William V. Boynton, Lunar and Planetary Laboratory, University of Arizona, Tucson, Arizona 85721. Letters of recommendation, directed as above, should be requested from at least three persons who are well acquainted with the applicant's accomplishments and potential. To receive full consideration, application materials should be received by August 31, 1981.

The University of Arizona is an equal opportunity affirmative action employer.

POSITIONS WANTED

Electro-Optical System Consultant. Electro-optical system consultant available to technically review and monitor the acquisition of custom remote and *in situ* instruments and systems. Box 005, American Geophysical Union, 2000 Florida Avenue, N.W., Washington, D.C. 20009.

SERVICES

Coal Deposits. If you are financing, planning, exploring, drilling, or digging in connection with any form of energy, you need this complete, up-to-date book about the world's coal deposits. Includes production and reserves for mines. Hardcover, 6 × 9 inches, 590 pages. Table of contents, drawings, index, references, 1980. $156. Tetech Associates, Thunder Road, Sudbury, MA 01776, USA.

Jet Stream. New journal of monthly world weather data and analysis. Sample from Westwind Services, c/o 2738 NW Quimby St, Portland, Oregon.

AGU

Membership Growth High

AGU's membership increased by 114.5% during the last 20 years—from 6200 members in 1960 to 13,300 in 1980—while the number of all natural and physical scientists grew 94.2%. The figures are from a survey of the membership growth pattern of the American Association for the Advancement of Science (AAAS), seven affiliated organizations, and six AAAS sections.

Members of AAAS more than doubled (growth of 111.9%) between 1960 and 1980, the survey showed. The biological sciences section had the biggest growth spurt (up 776.5%), and the mathematics section had the smallest (up 4.3%).

The American Mathematical Society had the largest growth—an increase of 198%—of the organizations surveyed; the American Chemical Society showed the least—30.6%—but it has more members (120,400 at 1980's count) than each association surveyed, except AAAS. Other organizations surveyed were the American Physical Society, the American Psychological Association, the American Sociological Association, and Sigma Xi.

During the last two decades the total number of Ph.D.'s in the sciences swelled 254.7%, slightly ahead of the total number of Ph.D.'s received in the two decades, regardless of field (220.6%). The United States' population, meanwhile, grew by only 25.4%.—*BTR*

Meetings

Water Resources Congress

A call for papers has been issued for the Fourth World Congress on Water Resources, scheduled for September 3–11, 1982, in Buenos Aires, Santa Fe, and Parana, Argentina; the congress was originally scheduled for August 27–September 4, 1982.

Topics to be covered at the congress include water and system engineering; educational, economic, and social aspects of water; environmental aspects of water; and water law and administration. The congress will focus on 'Water for Human Consumption, Man and His Environment.'

The congress is organized by the International Water Resources Association. Cosponsors and participants include the United Nations' Division of Natural Resources and Energy; the Organization of American States; the World Federation of Engineering Organizations; the International Association for Water Law; the Inter-American Association of Sanitary Engineering; the Pan American Engineers Union; the government of Argentina; Argentine Water and Electric Power; and the Argentine National Institute for Water Science and Technique.

September 1 is the deadline for abstracts of papers to be presented at the meeting. Ten copies of the abstract must be submitted to the Secretariat of the Congress in Buenos Aires. Another copy must be submitted to Glenn E. Stout, President of the U.S. Geographical Committee, Water Resources Center, University of Illinois, 2535 Hydrosystems Laboratory, 208 N. Romine, Urbana, IL 61801. Additional information on the congress can also be obtained from Stout.

Pacific Northwest Regional Meeting

September 17–18, 1981

Central Washington University
Ellensburg, Washington

Abstract Deadline: July 15

Last Call

Special symposia will be held on 'The Tectonics of the Columbia Plateau and Neogene-Quaternary Faults of the Pacific Northwest;' 'Stratigraphy and Structure of the Cascade Range;' and 'Studies of the Eruptions of Mount St. Helens.'

To submit an abstract, use standard AGU format (see page 20, January 13 *Eos*).

Send the original plus two copies to Bob Bentley, Secretary-Treasurer, PNAGU, Central Washington University, P.O. Box 1000, Department of Geology, Ellensburg, Washington 98926.

If you are not an AGU member, or if you are an AGU member who lives outside the Pacific Northwest region, and you wish to attend, write to Bob Bentley to have your name put on the mailing list.

The call was published in *Eos*, February 24.

AGU FALL MEETING
In the City by the Bay
San Francisco Dec. 7-11, 1981

Call for Papers

Abstracts must be received at the AGU office by 5 P.M. on September 18 to be on time. Late abstracts (1) may be summarily rejected by program chairman, (2) may not be published in advance of the meeting, and (3) if accepted, will be charged a $25 late fee in addition to the regular publication charge.

General Regulations

Abstracts may be rejected without consideration of their content if they are not received by the deadline or are not in the proper format. Abstracts may also be rejected if they contain material outside the scope of AGU activities or because they contain material already published or presented elsewhere. ONLY ONE CONTRIBUTED PAPER BY THE SAME FIRST AUTHOR WILL BE CONSIDERED for presentation; additional papers (unless invited) will be automatically rejected.

Only AGU members may submit an abstract. The abstract of a nonmember must be accompanied by a membership application form (with payment), or it must be sponsored by an AGU member.

There is a publication charge of $40.00 for each abstract ($20.00 if the first author is a student member.) Both invited and contributed papers are subject to the publication charge. The abstract must be received at AGU by September 18 to avoid an additional $25.00 charge.

AGU will acknowledge receipt of an abstract by returning a copy of it to the corresponding author. Notification of acceptance and scheduling information will be mailed in late October.

Ten minutes is normally allowed for the presentation of each contributed paper, and only 2" × 2" (35-mm) slide projectors and viewgraphs are usually available as standard equipment at the meeting. All other equipment is available at cost, plus a $10.00 billing charge if we have to invoice.

Instructions for Preparing Meeting Abstracts

The abstract page is divided into two parts: the abstract itself and the submittal information. Follow the instructions for both carefully. Please use a carbon ribbon to type the material, and do not exceed the maximum dimensions of the abstract of 10.4 cm by 20 cm. Abstracts that exceed the noted size limitations will be trimmed to conform to the proper dimensions.

The meeting program will be prepared by photographing the abstracts exactly as they are received. Use the model abstract to prepare the final version. Submission of an abstract for an AGU meeting is presumed to carry with it permission for AGU to reproduce the abstract in all editions of *Eos* and in the programs and reports relating to the meeting; it is also presumed to permit the free copying of those papers. Although *Eos* is a copyrighted journal, authors are not requested to transfer copyright; copyright, where it exists, will be reserved by the authors.

Submittal Information

Numbers refer to the items in the submittal block on the sample abstract.

1. Title of meeting.

2. Identification. (Only members may submit an abstract; this includes invited authors.)—Type identification number of one member author (ID number is the line consisting of 4 letters followed by 6 digits; see member's mailing label on *Eos* or journals) or if no author is an AGU member, type the ID number of the member sponsor. (Sponsor's name must also appear on the abstract at the end of the author portion.) If no ID number is given, a membership application and dues payment must accompany the abstract. Call AGU Member Programs (202-462-6903) immediately if you need an application.

3. Corresponding address.—Give complete address and phone number of author to whom all correspondence (acknowledgment and acceptance letters) should be sent. Abbreviate as much as possible.

4. Section of AGU to which abstract is submitted.—Use letter abbreviations of one of the following: G (Geodesy), GP (Geomagnetism and Paleomagnetism), H (Hydrology), M (Meteorology), O (Oceanography), P (Planetology), S (Seismology), SA (Aeronomy), SM (Magnetospheric Physics), SC (Cosmic Rays), SS (Solar and Interplanetary Physics), T (Tectonophysics), VGP (Volcanology, Geochemistry, and Petrology), U (Union).

5. Type title of special session (if any) to which submittal is made.

6. Indicate your preference for a particular kind of presentation by one of the following letters: O for oral, P for poster. The chairman may assign your paper to either of these types of presentation in order to fit his program plan.

7. Percent of material previously presented or published, and where.

8. Billing information
   a. Complete billing address if other than the corresponding address (item 3 above).
   b. If purchase order is to be issued, indicate number. (Please have issuing department list name of first author and title of paper on PO.)
   c. If student member is the first author, the student publication rate is applicable. Indicate 'student rate applicable.'

9. Indicate whether paper is C (contributed) or I (invited). If invited, list name of inviter.

Sample Abstract

```
TECHNIQUE FOR THE PREPARATION OF ABSTRACTS

F. R. S. T. Author (School of Oceanography
Hydro University, Watertown, Mass. 02172)
S. C. N. D. Author (USGS, Woods Hole,
Mass. 02543)
(Sponsor: I. C. Alvin)

Follow this example in typing the abstract.
The printing plates will be prepared by
photographing the abstracts exactly as
they are received, except that abstracts
exceeding the maximum length (20 cm) or
width (10.4 cm) will be cut to conform.
Use a good typewriter with a ribbon in
good condition. A carbon ribbon gives the
best results. Please use type of about this
size. There will be a reduction of about
50% for the printed abstract volume.
Follow these guidelines:
(1) Type title in all capital letters.
(2) Leave one line blank after title.
(3) Type name of first author, affiliation, and address.
(4) Type names of second and following
    authors, if any, leaving no blank
    lines between authors.
(5) Underscore the name of author who will
    present paper.
(6) Type sponsor's name if no author is an
    AGU member.
(7) Leave one blank after author
    block.
(8) Hand-lettered symbols or Greek letters
    are acceptable.
(9) Use SI units.

NOTE: There are no special forms distributed
for typing abstracts. If necessary this
block (10.4 x 20 cm) may be traced on
typing paper in nonreproducible blue pencil
or may be traced in dark lines on a backing
sheet. Be sure, however, to include all
information.
```

(20 cm)

(10.4 cm)

Submittal Information

(See explanation.)

1. Fall Meeting
2. AMER 052536
   or
   012548 ALVI (Sponsor)
3. Corresponding address:
   S.C.N.D. Author
   MS 123
   USGS
   Woods Hole, MA 02543
   617-548-1234
4. O (Oceanography)
5. Special Session:
   Deep-Sea Drilling
   (or none)
6. P (poster)
7. 10% at Midwest Meeting
8. a. Accounting Dept.
   Admin. Bldg.
   Hydro. Univ.
   Watertown, MA 02172
   b. P.O. #5684739
   c. Student rate applicable
9. C (Contributed)

Abstract Deadline: September 18
Mail original and two copies to Fall Meeting
American Geophysical Union
2000 Florida Ave., N.W.
Washington, D.C. 20009

SPR-Cosmic Rays and *SPR-Solar and Interplanetary Physics (SS/SC)*
George Gloeckler, University of Maryland
SPR-Magnetospheric Physics (SM)
Michael Schulz, Aerospace Corporation
Tectonophysics (T)
Marcia McNutt, USGS
Volcanology, Geochemistry and Petrology (V)
G. Brent Dalrymple, USGS

Program Committee

Meeting Chairmen
Martin Walt, Lockheed Missiles and Space Company
Geodesy (G)
Bob E. Schutz, University of Texas at Austin
Geomagnetism and Paleomagnetism (GP)
Maureen B. Steiner, University of Wyoming
Jack Hillhouse, USGS
Hydrology (H)
Edward D. Andrews, USGS
Meteorology (M)
Ronald C. Taylor, National Science Foundation
Oceanography (O)
Barbara Hickey, University of Washington
Planetology (P)
Richard Simpson, Stanford University
James B. Pollack, NASA Ames
Seismology (S)
Robert J. Geller, Stanford University
SPR-Aeronomy (SA)
Thomas A. Potemra, The Johns Hopkins University

Special Sessions

Geodesy
Results from Satellite Altimetera
The Gravity Field: Techniques, Instruments and Results

Geomagnetism and Paleomagnetism
Magnetite Biomineralization by Living Organisms

Hydrology
Impact of Richards' Equation: A Semicentennial Session
Symposium on Geophysics and Groundwater—Methods, Applications, Problems
Erosion—Sedimentation Processes in Mountainous Terrain
Groundwater Contamination: Product of a Technological Society
Characterization of Variability and Uncertainty in Water Quality

Meteorology
Thunderstorm Dynamics Electrification, and Recent Results from TRIP
The Use of Finite Elements in Meteorology and Oceanography

Oceanography
Marginal Ice Zone Processes
HEBBLE (High-Energy Benthic Boundary Layer Experiment)
West Coast Shelf Circulation
Vema Channel: Hydrography Geochemistry and Sediment Dynamics
Hawaii-Tahiti Shuttle Experiment
Mid-Latitude Large-Scale Variability
Dynamics of Coastal Circulation over Topographic Features
Coastal Oceanography
Paleoceanography
Estuarine Processes—Physical, Chemical and Biological

Planetology
Microwave Observations of the Planets
Volcanic Processes in the Solar System

Seismology
Multichannel Seismology
Observed Data from the Hazer Explosive

SPR-Cosmic Rays and Solar and Interplanetary Physics
Solar-Terrestrial Theory Program, Part II (Cosponsored by SPR-Magnetospheric Physics and SPR-Space Aeronomy)

SPR-Magnetospheric Physics
Aurora and Substorms (POSTER SESSION)
Plasma Waves and Instabilities in Space (POSTER SESSION)
Laboratory and Space Experiments
Solar-Terrestrial Theory Program Part I (Cosponsor: SPR-Cosmic Rays and SPR-Solar and Interplanetary Physics)
Magnetospheres of Jupiter and Saturn

Tectonophysics
Rheology of the Lithosphere
Sedimentary Basins

Volcanology, Geochemistry, and Petrology
Geology of Lohi Seamount
Chemical and Convective Stratification of the Mantle
Petro Genesis of Igneous Rock and Intraoceanic Volcanic Arcs
Volcanic Processes in the Solar System

GAP

Separates

To Order: The order number can be found at the end of each abstract; use all digits when ordering.

Cost: $3.50 for the first article and $1.00 for each additional article in the same order. Payment must accompany order.

Deposit Account: A minimum of $10.00 may be placed on deposit with AGU for the purchase of separates. If funds are on deposit, the cost of the first article is only $2.00 and $1.00 for each additional article in the same order.

Separates will be mailed within 3 weeks of journal publication or within 10 days if ordered after the journal has appeared. Separates are available for purchase for two years from date of publication.

Copies of English translations of articles from Russian translation journals are available either in unedited form at the time of their listing in EOS or in final printed form when a journal is published. The charge is $2.00 per Russian page.

Send your order to:
American Geophysical Union
2000 Florida Avenue, N.W.
Washington, D.C. 20009

Exploration Geophysics

0920 Magnetic and electrical methods
THREE-DIMENSIONAL RESISTIVITY INVERSION USING ALPHA CENTERS
W. R. Petrick, Jr. (Department Geology and Geophysics, 717 Mining Science Building, University of Utah, Salt Lake City, UT 84112) Wm. R. Sill and S. H. Ward

The method of alpha centers represents a class of solutions to the three-dimensional (3-D) dc conduction equation based on certain nonlinear substitutions for electric potential and earth conductivity. A solution is obtained which is sufficiently fast to make the inversion of 3-D resistivity data practical. The inversion routine results in a conductivity distribution defined by a concave which simultaneously fits the data from several parallel or perpendicular dipole-dipole profiles.

To illustrate the characteristics of this modeling approach, we apply the inversion algorithm to three theoretical and four field data sets. The four field data sets represent samples from massive sulfide and geothermal environments. The technique, when applied to theoretical data from prismatic bodies, gives fairly good estimates of the positions of conductive inhomogeneities but poor estimates of their actual conductivities.

The entire inversion algorithm requires less than 25,000 words of computer memory, thus making it accessible for small computers. We envision two major applications. The first is for in-field data interpretation to site drilling locations or to guide further exploration. The second is for obtaining a good initial guess for more sophisticated and costly multidimensional inversion schemes.
Geophysics, Vol. 46, No. 8

0930 Seismic methods
A RAY PARAMETER-INTERCEPT TIME SPECTRAL RATIO METHOD FOR SEISMIC REFLECTIVITY ANALYSIS
T. H. Brocher (Hawaii Institute of Geophysics, University of Hawaii, 2525 Correa Road, Honolulu, Hawaii 96822) and R. A. Phinney (Department of Geological and Geophysical Sciences, Princeton University, Princeton, New Jersey 08544)

A method is proposed for obtaining reflectivity amplitudes from seismic record sections which are densely sampled in the horizontal dimension. The technique consists of finding the spectral ratio of sub-critical (target) to post-critical (reference) reflection amplitudes. The method's novelty is that both target and reference amplitude spectra are estimated from slant (also known as ray parameter-intercept-time, p-tau or velocity) stacks of the record sections. The source-level is directly determined because the reference amplitude is totally reflected; source level estimation does not require knowledge of the impedance structure of the reference reflector. The technique functions well for reflections having low S/N ratios, little or no lateral continuity, poor near-surface velocity control and steep dips. Application of the method in the Consortium for Continental Reflection Profiling (COCORP) survey in the Rio Grande rift supports the interpretation that the large-amplitude mid-crustal reflection is a magma body.
J. Geophys. Res., Red, Paper 1S0594

0920 Seismic methods
[illegible]
J. Geophys. Res., Red, Paper [illegible]

0999 General or miscellaneous
DEVELOPMENTS IN EXPLORATION GEOPHYSICS, 1975-1980
Robert E. Sheriff (Consultant, Longs Peak Route, Fish Creek Road, Estes Park, CO 80517) Samuel J. Allen, G. James Gant, Jr., Robert S. Hodgson, Don S. Larson, J. Pat Lindsey, James R. Patch, Thomas R. LaFehr, G. R. Pickett, Wm. A. Schneider, J. Edward White, James C. Roberts

Advances in exploration geophysics have continued apace during the last six years. We have entered a new era of exploration maturity which will be characterized by the extension of our technologies to their ultimate limits of precision.

In gravity and magnetics, new inertial navigation systems permit the very rapid helicopter-supported land acquisition regions of severe topography. Considerable effort is being expended to obtain airborne gravity data via helicopter which is of exploration quality. Significant progress has also been made in processing and interpreting potential field data.

The goal of deriving the maximum amount of accurate subsurface information from seismic data has led to much more densely sampled and precise 2- and 3-D land data acquisition techniques. Land surveying accuracy has been greatly improved. The number of individually recorded detector channels has been increased dramatically (up to 1024) in order to approximate much more accurately a point-source, point-detector system. Much more powerful compressional-wave vibrators can now maintain full force while sweeping up or down from 5 Hz to near 200 Hz. In Marine surveying, new streamer cables and shipboard instrumentation permit the recording and limited processing of 96 to 480 channels. Improvements have also been made in marine sources and arrays.

The most important developments in seismic data processing—wave-equation based imaging and inversion methods—may be the forerunners of a totally new processing methodology. Wave-equation methods have been formulated for migration before and after stack, multiple suppression datum and replacement statics, velocity estimation, and seismic inversion. Inversion techniques which provide detailed acoustic-impedance or velocity estimates have found widespread commercial application. Wavelet processing has greatly expanded our stratigraphic analysis capabilities. Much more sophisticated 1-, 2-, and 3-D modeling techniques are being used effectively to guide data acquisition and processing, as direct interpretation aids, and to teach basic interpretation concepts. Some systems can now handle vertical and lateral velocity changes inelastic attenuation, curved reflection horizons, transitional boundaries, time-variant waveforms, ghosting, multiples and ray-response effects. Improved seismic display formats and the extensive use of color have been valuable in data processing, modeling, and interpretation.

Stratigraphic interpretation has evolved into three major categories: (1) seismostratigraphy, where regional and basinal geologic depositional environments; (2) qualitative stratigraphy, where specific rock units and their properties are mapped qualitatively to delineate lithology, porosity, and fluid; structural stratigraphy, where anomalies are mapped at a specific facies level to define net porosity-feet distribution, gas-fluid contacts, and probable pore fill. In essence, what began as direct hydrocarbon-indicator technology applicable primarily to Upper Tertiary clastics has now matured to utility in virtually every geologic province.

Considerable effort has been expended on the direct generation and recording of shear waves in an attempt to obtain more information about stratigraphy, porosity, and oil and gas saturation. Seismic service companies now offer shear-wave prospecting using vibrator, horizontal-impact, or explosive sources.

Well logging has seen the acceleration of computerization. Wellsite tape recorders and minicomputers with relatively simple interpretation algorithms are routinely available. More sophisticated computerized interpretation methods are offered as a service at data processing centers. A new "wall-hole" borehole gravimeter was developed and put in use in 1978. The instrument yields ... accuracy routinely.

Petroleum industry interest in electrical methods has increased, particularly in magnetotelluric (MT) and in active electromagnetic (EM) sounding. The improved MT method is still used primarily in reconnaissance. Renewed interest in EM "reflection" sounding stems from the success in direct hydrocarbon detection claimed by some service companies. ... is possible, but the electrical anomalies are attributed to measurable secondary effects in the overburden caused by upward-migrating hydrocarbons.

In minerals exploration, deeper and more costly drilling and generally higher exploration costs for more difficult targets have required the acquisition of increasingly larger amounts of independent geophysical (and geochemical) data. More expensive techniques such as reflection seismology, spectral induced polarization, and borehole logging with large suites of tools are becoming economically acceptable. More and better data acquisition has become possible with the rapid development of microelectronics. Minicomputers and microprocessors are employed both to control sensors and to record their outputs digitally in many airborne, surface, and borehole systems. Some contractors provide valuable initial digital data processing in the field. A trend away from anomaly detection and toward the synthesis of large suites of airborne, surface, and borehole measurements is evident.
Geophysics, Vol. 46, No. 8

Geodesy and Gravity

1930 Crustal Movements
QUATERNARY AND GEODETICALLY MEASURED CRUSTAL MOVEMENTS IN THE TOKAI DISTRICT, CENTRAL HONSHU, JAPAN
W. Thatcher (U.S. Geological Survey, 345 Middlefield Road M/S-77, Menlo Park, CA 94025) and T. Matsuda

Geodetic measurements made in this century demonstrate that modern movements correlate well with deformation that has occurred during the last 2 M.y. Both show effects of subduction and of the Quaternary collision of Izu Peninsula with Central Honshu. Westward from Suruga Bay, deformation is greatest near the coast, decreases markedly towards the uplifting Akaishi Mountains, and then increases again in the conjugate block-faulted terranes of Chubu district. Quaternary faults, historic earthquakes, and the distribution of horizontal shear straining since ~1880 all reflect this deformation pattern. Since 1900 the east coast of Suruga Bay has undergone secular subsidence, horizontal contraction and tilting towards Suruga Trough, all typical of the strain buildup process that occurs landward of subduction zones. However, further westward, active mountain building is occurring, and the Akaishi Ranges are rising 3 mm/a. Unlike the episodic aseismic uplift of the Transverse Ranges of southern California, movements here have been relatively uniform. It seems likely that an increase in the tilt rate of the Suruga coast recognized since ~1973 is part of a long-term readjustment to the great 1944 Tonankai earthquake. Data show that a monotonic increase has occurred since at least 1969, and similar effects are seen adjacent to the 1944 rupture zone over 200 km southwest along the Nankai Trough.
J. Geophys. Res., Red, Paper 1S0965

Izvestiya Atmospheric and Oceanic Physics
Volume 16, Number 6, 1980

CONTENTS

NOTES

CRITICS AND BIBLIOGRAPHY

CHRONICLE